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OXYGEN CONSUMPTION OF ANIMALS UNDER CONDITIONS OF HYPOKINESIA

Ye. V. Loginova, A. I. Volozhin, I. G. Krasnykh, Ye. A. Stroganova

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16. Abstract Three periods of gaseous exchange were revealed in rats under conditions of a limited motor activity. During the first 10-15 days O ₂ consumption displayed a sharp elevation; on the 20th-30th day, it became stabilized at a higher level (in comparison with control) and it sharply rose again on the 40th-100th day. In dogs hypokinesia produced a reduction of O ₂ consumption and then a tendency to its elevation was seen. A short period of physical exercises in squirrels after hypokinesia led to increased oxygen consumption at rest.			
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OXYGEN CONSUMPTION OF ANIMALS UNDER CONDITIONS OF HYPOKINESIA

Ye. V. Loginova, A. I. Volozhin, I. G. Krasnykh, Ye. A. Stroganova*

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Hypokinesia in puppies and baby rats is accompanied by increased gas exchange [2], and in adult dogs--by its reduction [4]. Data on changes in gas exchange in adult rats kept under conditions of hypokinesia is contradictory. Certain authors [1] have noted a reduction in oxygen consumption, while others [3, 4, 6] have noted an increase.

The purpose of this investigation was to study the influence of hypokinesia on the oxygen consumption of rats, dogs and squirrels. /33

Methodology. Tests were conducted on 350 white rats, 2 dogs and 8 squirrels. The activity of the animals was limited by means of placing them in individual cages. Cage sizes for the rats and dogs corresponded approximately to the size of the individual animal. The squirrels were kept in cages 35 x 35 x 40 cm in size. Oxygen consumption in the rats and squirrels was determined by the Kalabukhov method, and in the dogs--by the Douglas-Holden method. Measurement lasted 15 min. The data was expressed in millimeters of oxygen in 1 hr per 1 kg of the weight of the animal and cited against normal conditions. During determination of oxygen consumption by the Kalabukhov method, a constant temperature of 16° was maintained in

TABLE 1

Change in oxygen consumption (in ml/kg/hr) of rats depending on body weight ($M \pm m$)

	Weight (in grams)						
	110	140-150	160-170	180-190	200-210	220-240	260-350
Number of rats	9	20	25	57	30	60	60
Oxygen consumption	3044 ± 104	2350 ± 78	2328 ± 72	2318 ± 112	2249 ± 98	2139 ± 101	1766 ± 89

*Department of Pathological Physiology (directed by Acad. AMN SSSR Prof. N. A. Fedorov) Moscow Medical Stomatological Institute imeni N. A. Semashko

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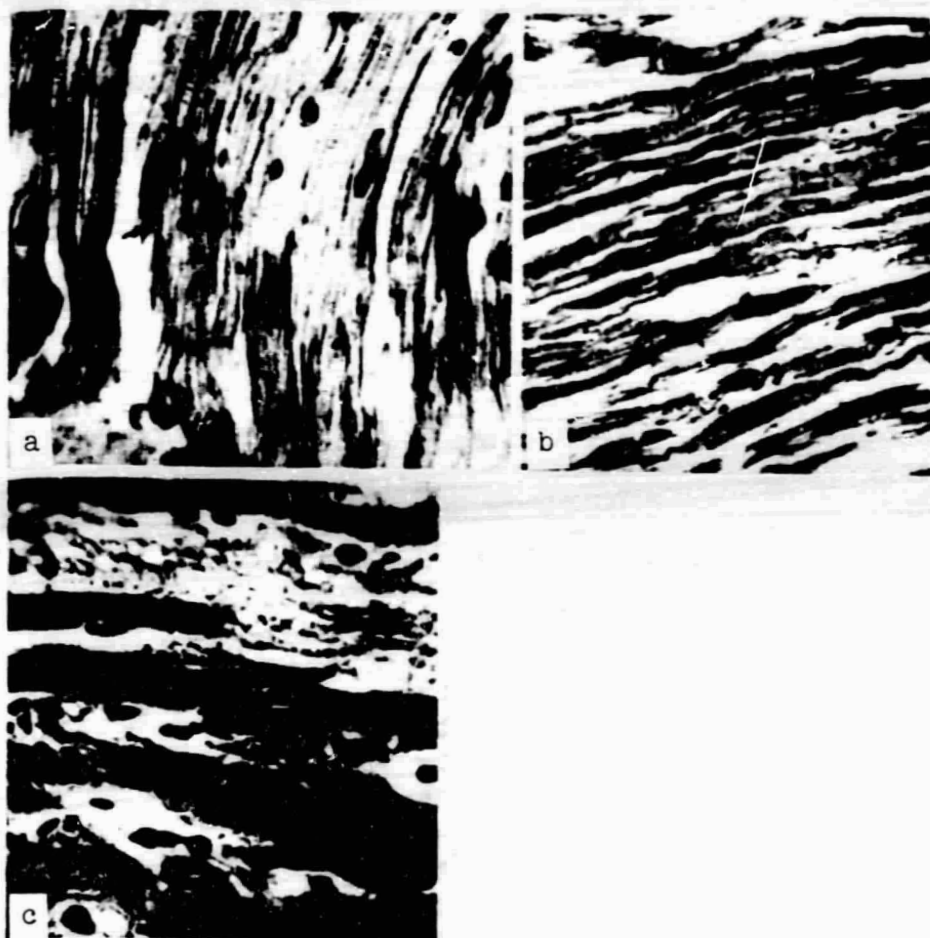


Figure 1. Changes in fibers of cardiac muscle in animals of the second group: a - structure of myocardium of intact rats. Magnification 7 x 40; b - amplification of longitudinal striation of myocytes and partial homogenization of fibers after 60 minute action of high temperatures. Magnification: 7x40; c - homogenization and fragmentary (chunks) decomposition of individual muscle fibers after 240-minute action of high temperature. Magnification: 7x90.

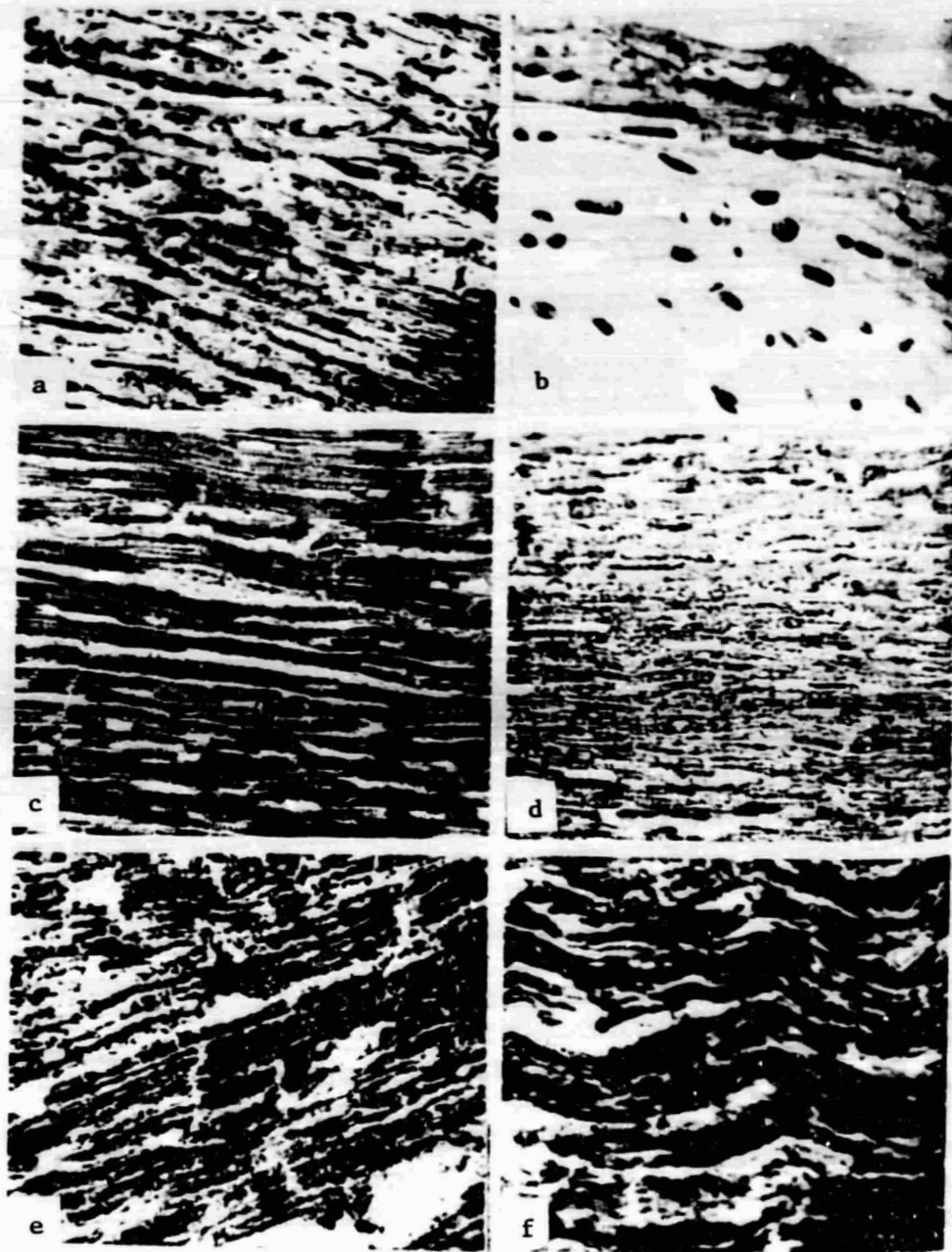


Figure 2. Changes in fibers in cardiac muscle in animals of the first group. a - content of glycogen in the myocardium of intact rates. Mag. 7X20; b - content of glycogen in the myocardium of rats after 240-minute action of high temperature. Mag. 7X40; c - activity of the SDG activity of the myocardium of intact rats. Mag. 7X40; d - SDG activity of rats after 240 minutes at high temperatures. Mag. 7X40. e-LDG activity of the myocardium of intact rats. Mag. 7X90. f-LDG activity of myocardium of rats after 240 minutes at high temperatures. Mag. 7X90

the chamber. Moisture and carbonic acid were absorbed. Considering the fact that the level of oxygen consumption is associated with the age, sex, and body size of the animals and the time of year [3, 5], the experiments on rats were set in 4 series. In series I, oxygen consumption depending on weight and sex of the rats was studied, in II -- during different times of the year, in series III and IV -- during hypokinesia.

In series III, rats with initial weight of 150 - 230 g. were used, in IV -- with a weight of 250 - 270 g. Animals of corresponding age found in conditions of free confinement were the control.

Table 2

Seasonal fluctuations in oxygen consumption (in ml/kg/hr) of rats weighing 160 - 230 g ($M \pm m$)

	Month of the year					
	I-II	III-IV	V-VI	VII-VIII	IX-X	XI-XII
Number of rats	50	20	30	10	20	20
Oxygen consumption	2265 \pm 77	2107 \pm 63	2263 \pm 93	2303 \pm 112	2373 \pm 89	2263 \pm 88

In the dogs named Snezhok and Zima (males aged $1\frac{1}{2}$ - 2 years), oxygen consumption and minute volume (MV) were studied before beginning the tests (background data), and then again on the 10, 20, 40th day and at the end of the 2, 3, 4, 5th and 6th months of hypokinesia.

All the squirrels were first kept for 5 days in ordinary cages, after which the animals were divided into 2 groups. Three squirrels were left

in the same cages (test), and 5 squirrels were placed for 2 days into the same size cages, but with an exercise wheel (control). The numerical data was processed by the Fisher-Student method.

Results and discussion. Rats weighing from 140 to 240 g consumed approximately the same amount of oxygen per 1 kg of weight (table 1). Compared with these, the oxygen consumption in younger rats was considerably higher ($P < 0.01$), and in older rats -- lower ($P < 0.05$). No differences were observed in the oxygen consumption of males and females.

Maximal oxygen consumption of rats was noted in September-October, and minimal -- in March-April (table 2). The difference comprised 12% ($P < 0.05$).

The cited data was considered in tests with hypokinesia. Experiments were conducted on rats of both sexes, of different age, and during different times of the year.

The limitation of motor activity of rats with initial weight of up to 230 g (table 3) was accompanied by an increase in oxygen consumption and a reduction in the rate of weight gain of the animals as compared with the control sample.

As evident from table 3, three periods may be distinguished in the change in gas exchange and weight of the rats, depending on the durations of hypokinesia. In the first period (10 - 15 days), oxygen consumption increased sharply and at the same time there was a reduction in body weight. In the second period (20 - 30 days), oxygen consumption approached the control level, and weight stabilized at a lower level than that of the control sample. In the third period (40 - 100 days) there was a further lag in weight gain of the rats accompanied by a sharp increase in oxygen consumption. The statistical data is reliable ($P < 0.01 - 0.001$).

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Table 3

The effect of hypokinesia on change in body weight and oxygen consumption of rats (M[†]m)

Length of test(days)	Weight of rats (in g.)			O ₂ consumption (in ml/kg/hr)			No. of rats	
	test	control	% of control	test	control	% of control	test	control
Initial weight 150-230 g (series III)								
10-15	144±7.9	186±6.6	77.4*	2959±62	2236±53	132.3**	30	40
20-30	155±9.2	207±5.4	74.9*	2700±97	2286±104	118.1*	40	40
40	171±8.3	228±7.0	74.2*	2943±93	2150±126	136.9**	15	20
60	167±7.0	251±7.2	66.6**	3093±80	2020±69	153.1**	29	30
100	184±5.1	301±6.9	61.1**	3310±114	1759±81	188.3**	9	10
Initial weight 250-270 g (series IV)								
10	185±4.4	279±4.6	66.3**	2378±53	1837±95	128.8**	10	10
20	188±6.9	286±8.9	65.7**	2299±86	1955±73	117.6*	10	10
40	184±6.3	306±11.3	60.1**	2576±69	1863±122	138.2*	10	10

* $P < 0.01$.
 ** $P < 0.001$.

In order to differentiate that part of changes in gas exchange in the rats which may be associated with the difference in body size between experimental and control animals, by the III series of experiments an additional group of young rats was taken as a control sample. These corresponded in weight to the experimental animals after 60 days of hypokinesia. The obtained data showed that oxygen consumption of the animals kept in conditions of hypokinesia for 60 days exceeded the corresponding indicator for the younger, control, rats by 41.7% ($P < 0.05$). Consequently, the basic reason for

the increase in oxygen consumption of the rats was hypokinesia, while the reduction in size of the animals had but a secondary significance.

In rats with initial weight of 250 - 270 g (see table 3, series IV), oxygen consumption under the influence of hypokinesia increased by approximately the same value as in rats with a lower initial weight. However, the lag in weight gain was expressed in greater degree for old rats than for the young.

Thus, hypokinesia in rats is accompanied by a drop in body weight and an increase in oxygen consumption. The higher oxygen consumption of rats in the experimental group as compared with the control sample cannot be explained on the basis of Rubner's law by the difference in weight and size of the rats [4]. A large part of this increase is associated with a change in exchange caused by the limitation of activity. At first, hypokinesia acts as stress [7], which in our experiments was expressed by an increase in oxygen consumption (first period), then (in the second period) there was the onset of short-term stabilization in weight and a certain reduction in exchange, which certain authors took to be adaptation [2, 8]. In the third period, a considerable increase in oxygen consumption was observed, which was evidently conditioned by the disruption of tissue metabolism [5, 6, 9].

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Hypokinesia in dogs for a period of 40 - 60 days led to a 6 - 11% reduction in body weight, after which the dog "Snezhok" experienced no change in weight to the end of the experiment, while the dog "Zima" experienced a gradual weight gain and by the end of the 6th month was only 2% below its initial weight. The change in gas exchange in the dogs had an undulating character (table 4): on the 20 - 30th days of hypokinesia, a 35 - 43% reduction in oxygen consumption was observed, and by the 40-60th day gas exchange in the dog "Zima" was 10% higher and in the dog "Snezhok"--10% lower than the initial

level. During subsequent time of hypokinesia, oxygen consumption of the dog "Zima" considerably exceeded the initial data while that of the dog "Snezhok" approached the value established before the experiment.

TABLE 4

Name of dog	Research indicator	Time (in days)									
		back-ground	10	20	30	40	60	90	120	150	180
Snezhok	MV l	7111	7586	5950	4958	6560	3600	3000	3866	3500	4393
	O ₂ consumption	9.10	8.69	6.73	5.17	8.21	6.70	5.90	7.95	8.39	7.69
Zima	MV l	3613	2633	4940	6120	3486	3333	3866	3000	3133	3567
	O ₂ consumption	7.48	5.26	4.96	6.12	6.26	8.90	8.14	7.66	9.49	9.17

Thus, the reduction in gas exchange observed in the dogs at the beginning of hypokinesia was replaced by its marked increase and by the end of the 6th month of hypokinesia, oxygen consumption of one of the dogs considerably exceeded the initial level of gas exchange.

The oxygen consumption of squirrels kept in cages without an exercise wheel (hypokinesia) was considerably lower (1567 ml/kg/hr) than under conditions of rest after two days of physical exertion (1989 ml/kg/hr). The data is reliable ($P < 0.05$).

Thus, our data indicated that the change in oxygen consumption during limitation of motor activity depends on the type of animal and duration of hypokinesia.

All authors who studied gas exchange in man noted a reduction in oxygen consumption in periods of up to 3 months of hypokinesia (cited according to [4]). For the present, there is no convincing explanation for the differences which exist in oxygen consumption during hypokinesia in man, dogs and rats. Evidently these differences are associated with the fact that the same durations of limited activity for man and various animals are not equivalent. In interpreting data on the effect of hypokinesia on gas exchange, it is necessary to also consider the duration of hypokinesia in relation to the lifespan of one or the other type of animal, as well as of man.

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